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# AN EXPERIMENTAL STUDY OF PARABOLIC WIRE-REFLECTORS ON A WAVE-LENGTH OF ABOUT 3 METRES


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Plate X


**ABSTRACT.** The paper presents the results of an experimental study of parasitic wire-reflectors arranged in a parabolic array on a wave-length of about 3 metres. The array had a focal length of $\lambda/4$ and the length of the wire-reflectors was $\lambda/2$. The primary antenna which was a grounded vertical $\lambda/4$-aerial connected to an ultra-short transmitter was placed at the focus of the parabola and the waves were received by a heterodyne receiving set constructed for the purpose. The relative field-strengths at a definite distance from the primary antenna were then measured for different orientations of the parabolic reflector. The polar distribution of the field-strengths was in this way studied :

(1) with *varying* numbers of the wire-reflectors in the array with a *fixed* spacing between the contiguous wires,

(2) with a *fixed* number of wire-reflectors of *varying* spacing values, and

(3) with a *constant* value of the aperture for the parabolic array of *varying* numbers of wire-reflectors.

The experimental study yielded information about the dependence of *forward radiation, total directivity, forward-sector directivity* and *back radiation* on the number, spacing and aperture of the parasitic reflectors in the parabolic array. A theoretical discussion of the experimental results has also been given in the paper.


## I. INTRODUCTION

There are generally two types of multiple antenna systems employed in directional wireless transmission : (1) the directly excited system, and (2) the parasitically excited system. In the first type all the wire-elements of the antenna-array are interconnected by transmission lines so that the phases and the magnitudes of the currents in the radiating elements are under control. In the second type there is a reflecting array of wires or metallic sheets which derives its energy through induction and radiation from the main or primary antenna or antenna-system. The relative dispositions of the wires in the reflecting array determine in this case the phases and magnitudes of the currents induced in the reflecting wires.

Much work has been done on the directional characteristics of antenna-arrays of the directly excited type and the results of these investigations have been utilised with much success in the commercial application of these arrays. Similar success has not, however, attended the use of parasitic wire-reflectors on a commercial scale, although this type of reflectors was first employed by Hertz [1] (1885-89) and afterwards by Marconi.[2] There may be many kinds of parasitic wire-reflectors, *viz.*, single, double, trigonal, trapezoidal, plane and parabolic arrays. Some amount of work on these wire-reflectors has already been reported. Mention may be made of Dunmore and Engels' [3] experiments with parabolic grid reflectors on a wavelength of 10 metres followed by Jones [4] who worked with similar reflectors on 3 metres. Englund and Crawford [5] investigated the effect of idle antennas in the neighbourhood of an excited one. More recently the directional characteristics of solid metal- and wire-reflectors were studied by Gresky [6] (2·08 metres), Kohler [7] (16·8 cm.), Beauvais [8] (15 to 17 cm.) and others and very recently by Nagy [9] (2·5 metres). The commercial possibilities of the parasitic reflectors were indicated by the work of Yagi,[10] Uda,[11] Meissner and Rothe,[12] Merconi and Franklin,[13] Clavier,[14] Esau and Hahnemann,[15] Wolff, Linder, and Braden,[16] Kolster [17] and others.

In the present investigation an experimental study has been made of the intensity distribution in a horizontal plane due to the juxtaposition of a vertical antenna and parallel parasitic wires arranged in a parabolic array. It was thought desirable to obtain reliable information about the effect of the number and the spacing of the reflector-elements and of the aperture of the parabolic array on the directional characteristics of such an array. Adequate precaution was necessarily taken in the experimental arrangements to minimise extraneous radiation by placing horizontally, as far as practicable, all idle and current-carrying elements which did not form an integral part of the radiating unit. This resulted in a fair degree of symmetry of the polar radiation patterns so that the conclusions and deductions from these polar patterns are to a great extent reliable. Placing the primary antenna of a small-power ultra-short-wave transmitting set at the focus of the parabolic array, the polar energy distribution at some distance from the reflector was investigated for different values of the number and spacing of the wires and for different apertures of the parabolic system.

The results of these investigations are embodied in this paper and finally some approximate theoretical formulae for parabolic array of the parasitically excited type are discussed in the light of the experimental results.

## 2. EQUIPMENT

### *The Parabolic Reflector*

The reflector-elements of the parabolic array consisted of S.W.G. No. 12 copper wires of length 150 cm. (approximately half the wave-length employed in this investigation). Two similar parabolic wooden frames of about 4 metres aperture, one fixed at a height of 70 cm. above the other in a parallel position, were fitted up with small ebonite discs 10 cm. apart and copper rods were inserted vertically through the holes drilled through the two sets of ebonite discs one above the other in the two wooden frames. Each rod could be fixed in position by a short stout wire inserted transversely at one end of the rod. The double wooden structure was held up at a convenient height by wooden supports so that the distance of the middle of each reflector wire from the ground was about 115 cm. The entire structure was so designed as to permit 360° rotation about a vertical axis through the vertex of the parabola. The focal length of the parabola was 75 cm., *i.e.*, approximately a quarter of the wave-length employed in this work.

### *The Transmitter*

The circuit diagram of the transmitting set is given in figure 1. A Telefunken R. E. 134 valve was connected to a single tuned circuit with capacitive retro-action. A voltage of above 250 volts was employed for the direct current supply for the anode circuit. Suitable choke coils having self-resonance at approximately the working wave-length were placed with their axes horizontal in all the D. C. supply leads to the valve electrodes. The transmitting aerial was practically a $\frac{\lambda}{4}$-aerial and the wave-length of the radiation was 2·88 metres. The lower end of a straight S.W.G. No. 12 wire fixed in a vertical position was connected to one end of a small loop of wire which was also placed in a horizontal

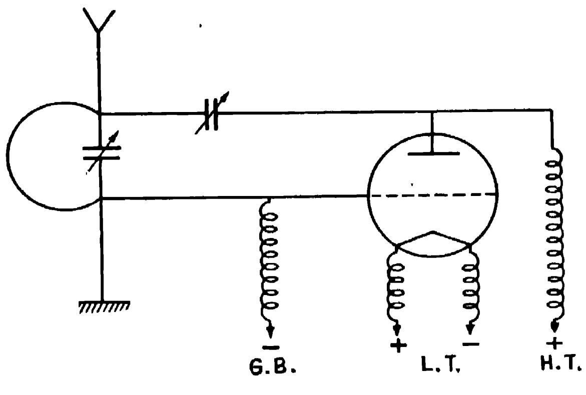



FIGURE 1

plane. This end was also connected to the retro-active condenser. The other end of the horizontal loop which was about 20 cm. above ground was connected to the earth by a straight vertical wire. Immediately above the loop was placed an ammeter to indicate the constancy of the aerial current. A sliding copper tube placed concentrically over the upper part of the vertical aerial was found convenient for the tuning purpose.

A light wooden frame with a horizontal wooden board on the top protected the components of the oscillator from wind and dust. The base board of the frame was fixed on four insulated supports. The aerial supported by a light wooden structure projected directly above the top board of the oscillator. Above this board the ammeter was fitted to the wooden structure supporting the aerial. The distance of the top end of the aerial from the ground was 77 cm. The photograph of the transmitter with the parabolic wire reflector is shown in figure 1(a), Plate X.

*The Receiving Arrangement*

The receiver constructed for the measurements of relative field intensity comprised a detector-oscillator unit. This stage was used in an oscillating condition for the heterodyne reception of the waves from the transmitter. After rectification the beat-note of audible frequency was passed through an amplifying stage. A low frequency choke was inserted in the anode circuit of the amplifier and a pair of telephones was connected through a large condenser (1 $\mu$ F) to the anode end of the low frequency choke and the negative end of the low tension battery feeding the filament of the amplifier. The low freqnency potential difference across the telephones was then measured in arbitrary units by means of a valve-voltmeter constructed for the purpose. The circuit diagram of the receiver is shown in figure 2(a). The detector-oscillator valve used was a Philip's T. C. 03/5 valve and the amplifying valve was a B 443 valve with a suitable bias voltage to the control grid. The receiving aerial was similar to the transmitting aerial. The distance of the top end of the aerial from the ground was 87 cm.

An A.C.S.G. valve fed by direct current was employed in the valve-voltmeter After having applied suitable voltages to the anode and screen-grid the micro-ammeter which was in the plate circuit was balanced in the manner shown in figure 2(b). With the signal on, a change in the deflection of the micro-ammeter was observed. In all cases the readings of the micro-ammeter deflections were taken with a telescope placed at a distance of about 6 metres from the receiver. The complete receiving arrangement was fixed upon a wheeled carrier.

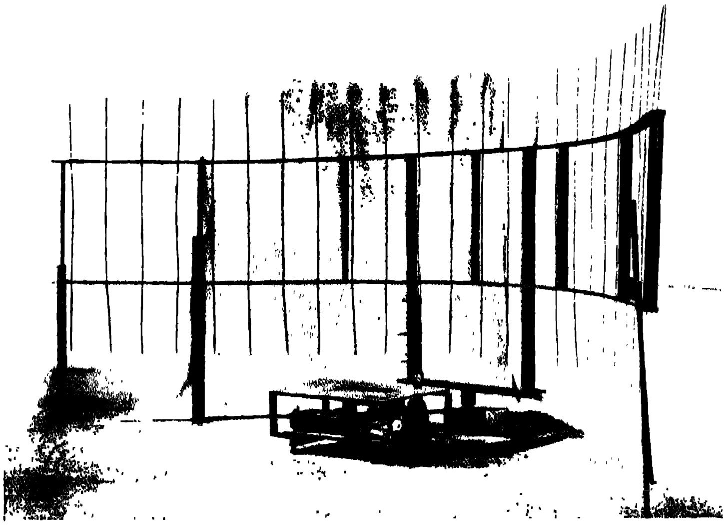


Figure 1 (a)

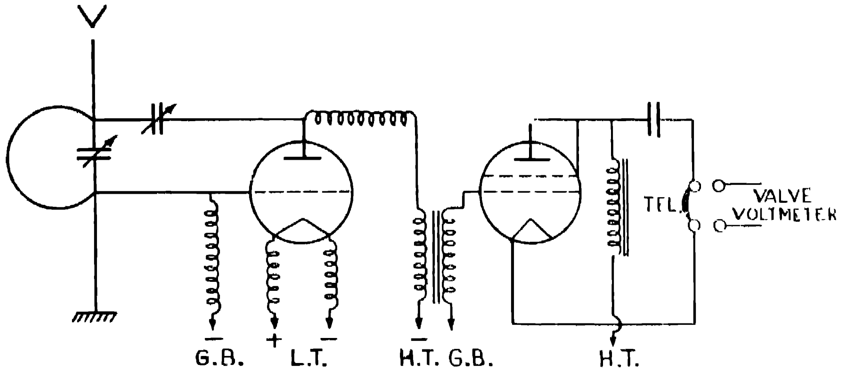



FIG. 2 (a).

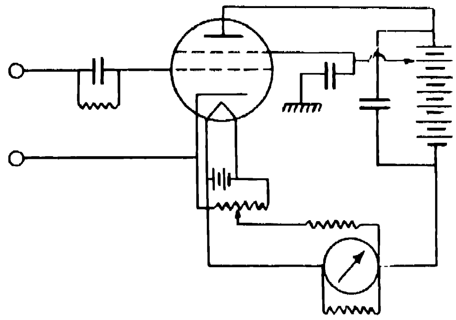


FIG. 2 (b).

To make the transmitting and receiving sets as light as possible, low tension batteries were used separately on insulated stands on the ground.

The tuning condenser in the detector-oscillator circuit was fitted with a long ebonite handle and once the adjustment of wave-length of the oscillation in the detector-oscillator circuit was made by turning this handle, the position of the tuning condenser was kept fixed throughout one set of observation of the micro-ammeter deflections.

The response curve of the receiver showing the change in the micro-ammeter deflection for different values of current in the transmitting aerial was found to be a straight line, except for extremely small aerial currents. The receiver current could, therefore, be taken as directly proportional to the field-strength due to the transmitter at a distance.

## EXPERIMENTAL PROCEDURE

The experiments were carried out on level earth practically free from the disturbing effect of trees, underground circuits, etc. On the experimental site a circle of radius equal to 75 cm. was first marked out and the antenna of the transmitter was placed exactly at the centre. The receiver was placed at a distance of 10 metres from the transmitting antenna. The straight line joining the two antennas was taken as the zero degree line. Several diameters were then marked on the circle, making different angles with the zero-line so that the parabolic reflector at its vertex could be placed tangentially along the circle with its axis oriented at different angles (0° to 360°) from the zero-line.

At first the measurement of the relative field-intensity was made without the parabolic reflector. After removing the reflector the aerial current of the transmitter was adjusted to some definite value. (The observation of the aerial current was made through a telescope situated at some distance from the transmitter.) The receiver was then adjusted and the change in the deflection of the micro-ammeter in the valve-voltmeter of the receiving set measured with the transmitter on and off. The parabolic reflector was then brought and placed tangentially at its vertex along the circle marked on the ground at the points corresponding to the ends of the diameters marked out previously Thus for these different positions the axis of the parabola made different angles with the straight line joining the transmitting and the receiving antennas. Keeping the aerial current in the primary antenna the same as before, the changes of micro-ammeter deflections at the receiving end were then measured successively with the transmitter on and off for the different orientations of the parabolic reflector. The polar diagram of the distribution of the relative field-intensity in a horizontal plane was then constructed.

Three distinct cases were investigated :

(1) Experiments with a *constant spacing* of the reflector-elements of *varying numbers* and consequently of varying apertures of the parabolic reflector.

(2) Experiments with a *fixed number* of *reflector-elements* of *different spacing-values.*

(3) Experiments with a *fixed aperture* of *varying numbers* of *reflector-elements.*

In all these cases the length of the wires was 150 cm.

## EXPERIMENTAL RESULTS

The polar distribution of the radiation from the transmitting antenna without the reflector was first determined. The intensity distribution was found to be practically uniform in all directions. The experimental results with the parabolic reflector are given in three different sets.

### Set I. *Study of polar patterns of the parabolic reflector with a fixed spacing (20 cm.) of the reflector wires*

The polar distribution of energy with 25, 19, 13, 7 and 3 wires of fixed spacing in the parabolic reflector was determined. A typical set of readings is shown in table I. The corresponding polar diagram is given in figure 3.

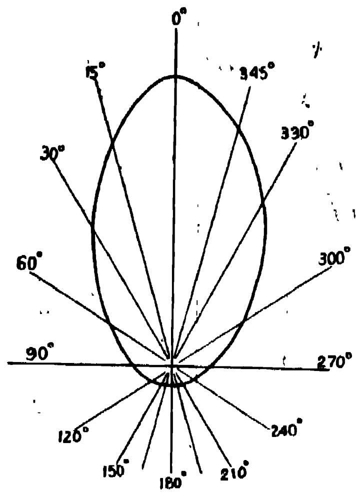



FIGURE 3

TABLE I

Spacing : 20 cm.

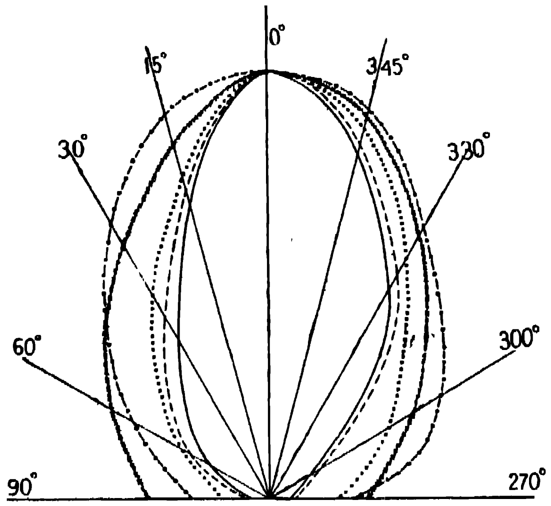
Number of wires : 13. Aperture : 224 cm. = $7.8\lambda$

Primary aerial current: ·21 amp.

Receiver current without reflector = $8\mu A$

| Orientation of the reflector. | Receiver current (micro-amps.). | Orientation of the reflector. | Receiver current (micro-amps.). |
|---|---|---|---|
| 0° | 18 | 90° | 2 |
| 15° | 14 | 270° | 3 |
| 345° | 16 | 120° | 1 |
| 30° | 10 | 240° | 1 |
| 330 | 12 | 150° | 1 |
| 60° | 4 | 210° | 1 |
| 300° | 6 | 180° | 1 |

Figure 4 is constructed to represent graphically the change in the beam-shape with the change in the aperture of the reflector and consequently with the change in the number of wires when the spacing is kept constant. The receiver current $I_\phi$ for any particular orientation $\phi$ of the reflector is divided by the value of the




N = 25 APERTURE 1·37λ
N = 19 ,, 1·097λ
N = 13 ,, ·78λ
N = 7 ,, ·41λ
N = 3 ,, ·14λ
SPACING=20 CM. $=\frac{\lambda}{14\cdot4}$, LENGTH OF WIRES $\approx \frac{\lambda}{2}$ $\lambda$=288 CM.

FIGURE 4

receiver current I without the reflector. This ratio is then expressed as a percentage of the maximum value $I_0$ in the forward direction. These percentage values are then shown for different orientations of the reflector in the sector 270°, 0° and 90°. The data for this comparison diagram prepared from the relevant readings of the different polar patterns are given in table II.

TABLE II

| Orientation of the reflector. | Percentage values of : $\frac{I_\Phi}{I}/I_0$ | | | | |
|---|---|---|---|---|---|
| | N=25 | N=19 | N=13 | N=7 | N=3 |
| 0° | 100 | 100 | 100 | 100 | 100 |
| 15° | 73·2 | 74·0 | 77·8 | 85·7 | 94·3 |
| 345° | 86·7 | 85·1 | 88·9 | 92·8 | 94·3 |
| 30° | 43·2 | 51·8 | 55·6 | 57·2 | ... |
| 330° | 60·6 | 66·7 | 66·6 | 71·4 | 60·3 |
| 60° | 16·7 | 22·2 | 22·2 | 42·9 | 37·15 |
| 300° | 13·2 | 14·7 | 33·3 | ... | 37·15 |
| 90° | 3·3 | 3·7 | 11·1 | 28·6 | 17·1 |
| 270° | 3·3 | 7·3 | 16·7 | 21·4 | 22·9 |

The lateral and back radiation for the reflector within 90° and 180° are depicted in figure 5. The ordinates are the values of the receiver current in per cent. of the maximum forward radiation. In table III are given the data.

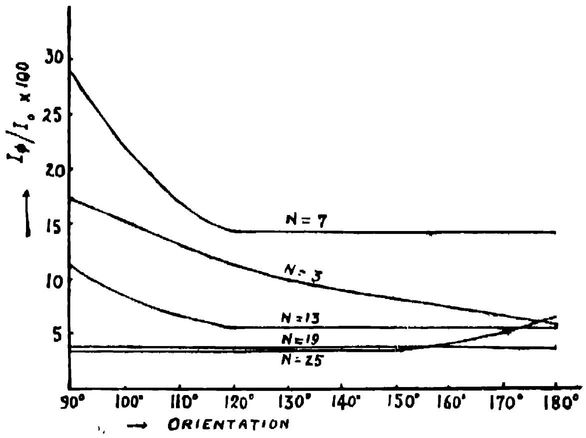



FIGURE 5

TABLE III

| Orientation of the reflector. | Percentage values of : $I\phi/I_0$ | | | | |
|---|---|---|---|---|---|
| | N=25 | N=19 | N=13 | N=7 | N=3 |
| 90° | 3·3 | 3·7 | 11·1 | 28·6 | 17·2 |
| 120° | 3·3 | 3·7 | 5·55 | 14·3 | 11·4 |
| 150° | 3·3 | 3·7 | 5·55 | 14·3 | 8·6 |
| 180° | 6·7 | 3·7 | 5·55 | 14·3 | 5·7 |

DEDUCTIONS FROM THE POLAR PATTERNS (Set I)

Before setting out the deductions from the above experimental study, the different symbols and terms used to characterise the directional properties of the parasitic reflector should be clearly defined :

$l$ = length of the reflector-element.

S = separation of the reflector-elements.

$2a$ = aperture of the parabolic reflector, *i.e.*, the straight-line distance between the two outermost elements in the array.

$N$ = number of reflector-elements in the array.

$\phi$ = orientation of the reflector from the $0° - 180°$ axis.

$I$ = receiver current without reflector.

$I_\phi$ = receiver current with reflector for any value of $\phi$.

$I_0$ = forward radiation, *i.e.*, receiver current when $\phi = 0$.

$\mu$ = *power amplification factor* of reflector, *i.e.*, the ratio of the receiver current with reflector for $\phi = 0$ to the receiver current without reflector, $[\mu = I_0/I]$.

$\delta$ = *total directivity*, *i.e.*, the ratio of the area of a circle with radius $I_0$ to the area of the entire polar pattern.

$\Delta$ = *forward-sector directivity*, *i.e.*, the ratio of the area of a semi-circle with radius $I_0$ to the area of the polar pattern contained within the sector $270°$, $0°$ and $90°$.

$\beta$ = back radiation, *i.e.*, the maximum value of the current in the sector $90°$, $180°$ and $360°$ expressed in per cent. of $I_0$.

$\beta_{180°}$ = value of the receiver current for $\phi = 180°$ in per cent. of $I_0$.

In table IV are given the values of $\mu$, $\delta$, $\Delta$ and $\beta$ for the polar patterns of Set I.

TABLE IV

$S = 20$ cm. $= \cdot069\lambda$ ; $\lambda = 2\cdot88$ metres

| No. of wires. | Aperture. | $\mu$ | $\delta$ | $\Delta$ | $\beta_{180°}$ | $\beta$ |
|---|---|---|---|---|---|---|
| 25 | $1\cdot37\lambda$ | 3·3 | 7·9 | 3·9 | 6·7 | 6·7 |
| 19 | $1\cdot10\lambda$ | 3·0 | 7·1 | 3·6 | 3·7 | 7·4 |
| 13 | $\cdot78\lambda$ | 2·2 | 6·5 | 3·35 | 5·6 | 16·6 |
| 7 | $\cdot41\lambda$ | 1·8 | 4·4 | 2·5 | 14·3 | 28·5 |
| 3 | $\cdot14\lambda$ | 2·3 | 5·1 | 2·7 | 5·7 | 22·9 |

In figures 6(*a*) and 6(*b*) are illustrated the variation of $\mu$, $\delta$, $\Delta$ and $\beta$ with the change of aperture of the reflector.

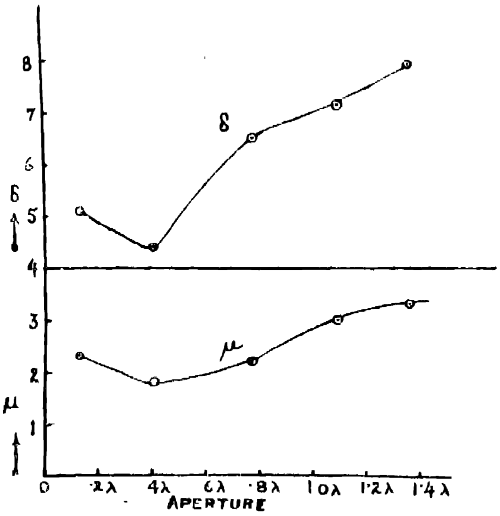



FIGURE 6(*a*)

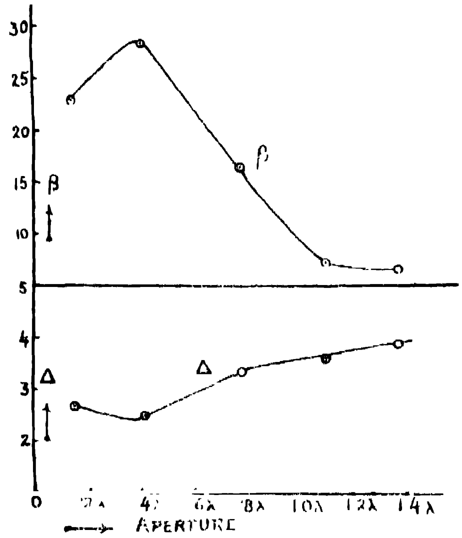



FIGURE 6(*b*)

The following is a summary of these results with conclusions and explanatory notes :

(1) With a constant spacing (20 cm.) and a constant length (150 cm. $\simeq \frac{\lambda}{2}$) of the wires, the forward radiation or the power-amplification factor of the reflector was found in general to increase with the increase of aperture. A diminution was, however, observed for $0{\cdot}41\lambda$ aperture. From considerations of phase relations it is evident that forward radiation may not continuously increase with the increase of aperture and may actually show a diminution for a certain increment of aperture. When the aperture is increased by the addition of an element to each side of the axis of the reflector, the phases of the field due to these added elements may be such as to cause 'destructive interference' so that the forward radiation may be 'nullified.' Additional elements will, however, compensate for this diminution and forward radiation will then increase with aperture till an unfavourable aperture-value is attained where the condition for destructive interference will prevail. The forward radiation is expected accordingly to reach a limiting value, when with further addition of wires the outermost reflector-elements will not materially contribute either additively or subtractively, since the induced currents in these outermost elements will necessarily be small. This limiting aperture according to Gresky, Kohler and Nagy is in the region of $1{\cdot}4\lambda - 1{\cdot}5\lambda$. It will be seen from figure 6(*a*) that the forward radiation tends to approach a constant value for the larger apertures.

(2) With the same spacing and the same wire-length, the forward-sector directivity increased in general with the increase of aperture and so also the total directivity. (See figure 6*b*.)

It is to be emphasised that the consideration of the phase-relationship is of prime importance. The aperture cannot, therefore, be always an index of amplification and directivity. It will be shown later that the amplification and the directivity of the reflector are altered by changing the number and the spacing of the elements even with the same aperture.

(3) Under similar reflector conditions the backward radiation seemed to be reciprocally related to the amplification and the directivity, *i.e.*, a large amplification or directivity was found to be associated with a small back radiation. This is illustrated in figure 7 where the back radiation is plotted against amplification. It will, however, be shown later that this state is not generally true.

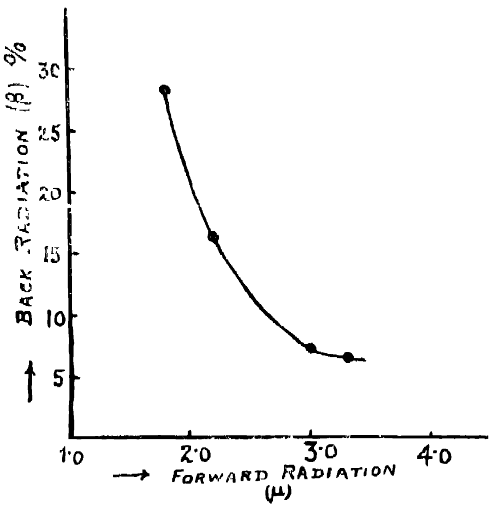



FIGURE 7

(4) Under similar conditions, the general nature of the variation of back radiation is a gradual diminution with the increase of aperture with a tendency to approach a steady value (figure 6*a*). This should be so, since back radiation is determined principally by the elements in the neighbourhood of the vertex of the parabolic array.

Set II. *Study of polar patterns of parabolic reflector having a constant number of reflecting wires with different spacings*

Polar patterns of a 7-wire parabolic array for six different spacings (10 cm., 20 cm., 30 cm., 40 cm., 50 cm. and 80 cm.) were constructed.

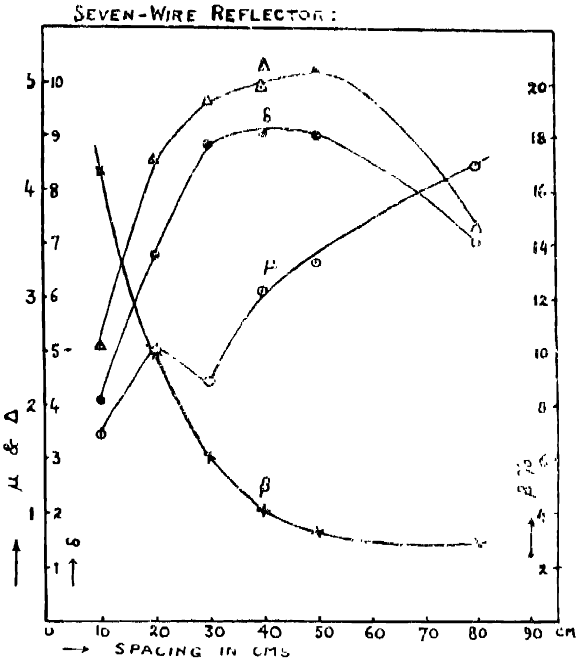



FIGURE 8

The power-amplification factor $\mu$, the total directivity $\delta$, the forward-sector directivity $\Delta$ and the back radiation $\beta$ are calculated from the experimental data. These are incorporated in table V. The results are illustrated in figure 8.

TABLE V

7 wires $\lambda = 2{\cdot}88$ metres

| Spacing. | Aperture. | $\mu$ | $\delta$ | $\Delta$ | $\beta_{180°}$ | $\beta$ |
|---|---|---|---|---|---|---|
| 10 cm. = ·035λ | 20·5 cm | 1·71 | 4·09 | 2·54 | 16·7 | 25 |
| 20 cm. = ·069λ | 40·4 ,, | 2·50 | 6·79 | 4·26 | 10·0 | 20 |
| 30 cm. = ·10λ | 50·3 ,, | 2·23 | 8·87 | 4·84 | 6 1 | 10·20 |
| 40 cm. = ·14λ | 80·1 ,, | 3·06 | 9·09 | 4 96 | 4·0 | 12·24 |
| 50 cm = ·17λ | 100·0 ,, | 3·33 | 9·05 | 5·1 | 3·3 | 10·0 |
| 80 cm. = ·28λ | 395·5 ,, | 4·25 | 7·08 | 3·65 | 2·94 | 5·88 |

DEDUCTIONS FROM THE POLAR PATTERNS (SET II)

(1) Using a 7-wire reflector of constant wire-length, the power-amplification factor was found in general to increase with the increase of spacing. It is expected, however, from consideration of phases that the forward radiation may not always be an increasing function of spacing. In our experiment, the forward radiation for S=30 cm. showed a diminution and increased again with the increase of spacing. (See figure 8.)

(2) With the same number of wires of constant length, the total directivity and the forward sector directivity were found to increase with the increase of spacing, each attaining a maximum in the region 50 cm. (·17 λ) after which there was a diminution. (See figure 8).

(3) Under similar conditions, the back-radiation at 180° was found to diminish continuously with the spacing tending to approach a constant value. (See figure 8.)

Set III. *Study of polar patterns of the parabolic reflector of constant aperture with different numbers of wires*

Polar patterns of the parabolic array with 1·37λ aperture (395·5 cm.) having 25 wires of spacing 20 cm., 13 wires of spacing 40 cm., 7 wires of spacing 80 cm. and 3 wires of spacing 240 cm. were constructed.

The values of power-amplification factor, total directivity, forward-sector directivity and back radiation calculated from the data are given in table VI.

TABLE VI

Aperture = 1·37λ    λ = 2·88 metres

| No. of wires. | Spacing S | $\mu$ | $\delta$ | $\Delta$ | $\beta_{180°}$% | $\beta$% |
|---|---|---|---|---|---|---|
| 25 | 20 cm. | 3·33 | 7·7 | 3·02 | 6·06 | 6·06 |
| 13 | 40 cm. | 3·5 | 6·93 | 3·56 | 3·6 | 7·1 |
| 7 | 80 cm. | 4·25 | 7·08 | 3·65 | 2·94 | 5·88 |
| 3 | 240 cm. | 3·125 | 12·08 | 9·1 | 16 | 16 |

These results are illustrative of the statement previously made, *viz.*, the aperture is not always an index of amplification or directivity, for with the same aperture we see an increase or a decrease of forward radiation or directivity with different numbers of wires of varying separations. Again, it is not *generally* true that back radiation is small when the directivity is large or *vice-versa.* It is clear from table VI that with 3 wires of 2.40 cm. spacing, the back radiation was considerable and the directivity was also large.

## 5. THEORY OF PARABOLIC ARRAY OF PARASITIC WIRES

An approximate theory of the parabolic reflector has been worked out by A. Hund by the application of Huyghens' principle according to which the radiation can be imagined as being due to fictitious radiators which lie in the front face of the reflector. The directional characteristic (in a horizontal plane) of a vertical antenna with a parabolic reflector is accordingly given by

$$I_{\phi} = I_0 . \frac{\sin\left[\frac{2\pi}{\lambda} a \sin \phi\right]}{\sin \phi} \qquad \ldots \quad (1)$$

F. Ollendorff has also derived a similar formula for the field-strength in a horizontal plane of a parabolic array of vertical elements. Considering the effect of the reflector as equivalent to that of a metallic sheet carrying a current of constant amplitude, the expression for the field-strength is given by

$$I_{\phi} = K\left[\frac{\sin (2\pi/\lambda . a \sin \phi)}{\sin \phi}\right] \qquad (2)$$

where $K = \frac{l i}{\pi \epsilon_0 c r}$

$l$ = length of the reflector-element ;

$i$ = current density ;

$\epsilon_0$ = dielectric constant of vacuum ;

$r$ = distance from centre of aperture to receiver ;

$c$ = velocity of light ;

$a$ = half aperture of reflector ;

and $\phi$ = orientation of reflector from the zero degree line.

We shall now examine Ollendorff's formula and see how far it agrees with our experimental results.

I. *Forward Radiation*

By differentiating the numerator and the denominator of (2) separately, we can obtain the magnitude of the forward radiation from

$$I_\phi = K \frac{\cos\left(\frac{2\pi a}{\lambda} \sin\phi\right) \cdot \frac{2\pi a}{\lambda} \cos\phi}{\cos\phi}$$

On putting $\phi = 0$, we get $I_0 = k.a$, where $k = \frac{2\pi K}{\lambda}$. This relation is only approximately satisfied within a limited range of apertures as is evident from figure 9(*b*) where the results of our experiments (Set I) are compared with the results expected according to Ollendorff's formula.

II. *Forward-Sector Directivity*

The values of forward-sector directivity $\Delta$ are computed from the polar diagrams constructed according to Ollendorff. The theoretical and the experimental values in arbitrary units are shown for comparison in figure 9(*a*). The similarity only lies in the fact that both theoretically and experimentally there is an increase of $\Delta$ with aperture.

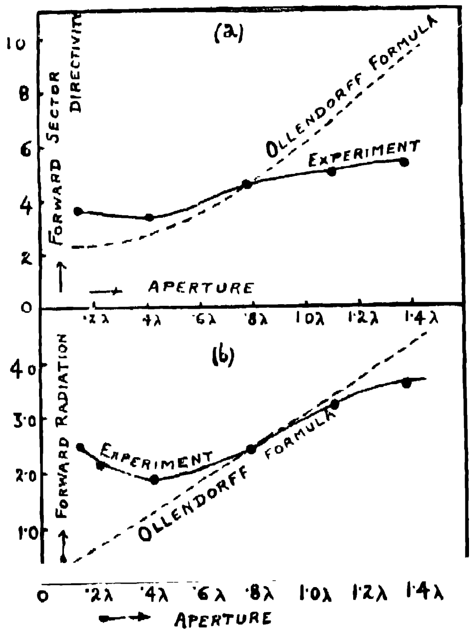



FIGURE 9

It should be remembered that, for Ollendorff's formula to hold, the arrays should produce effects similar to those of metallic sheets. According to Blake and Fountain [20] the spacing must then be $\frac{\lambda}{30}$ or $\frac{\lambda}{40}$. Complete agreement with theory is not, therefore, expected since the spacing employed in the experiments, the results of which are considered here, is about $\lambda$.

## 6. SUMMARY

The results of an experimental study of a parabolic wire-reflector on a wave-length of 2·88 metres are given in this paper. The parabolic array had a focal length of about $\frac{\lambda}{4}$. The main results of this study are enumerated below :—

(1) With a spacing of ·069λ (=20 cm.) the a constant wire-length of $\frac{\lambda}{2}$, the forward radiation and the directivity were, in general, found to increase with the increase of aperture. A diminution was, however, noticed at a certain increment of aperture. The range of aperture was from ·14λ to 1·37λ and the number of wires was varied from 3 to 25. There was an indication of a limiting value of the forward radiation for the larger apertures.

(2) Under similar reflector conditions, a large amplification or a large directivity seemed to be associated with a small back-radiation and the latter was found in general to diminish with the increase of aperture.

(3) With a seven-wire parabolic reflector of the same wire-length as before, the forward radiation was found in general to increase with the increase of spacing. Under similar conditions the total directivity and the forward-sector directivity increased with the increase of spacing, each attaining a maximum in the region S=·17λ (=50 cm.). The back-radiation at 180° was found to diminish with the increase of spacing with a tendency to approach a constant value. The spacing ranged from ·035λ to ·28λ.

(4) The aperture was not always found to be an index of amplification and directivity; for, with the same aperture, an increase or a decrease of forward radiation and directivity was observed with different numbers of wires of varying spacing values.

(5) The statement in (2) is not also generally true, for working with a constant aperture, sometimes a large directivity with a relatively large amount of back-radiation was found, depending on the number and the spacing of the wires.

The experimental results have been used finally to discuss an approximate formula deduced by Ollendorff.

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